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Checklist of the snakes of Nova Ponte, Minas Gerais, Brazil

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Manuscript received: 13 August 2013

Accepted: 22 January 2014 by DENNIS RÖDDER

The Cerrado is the second largest phytogeographic region in Brazil, and considered a hotspot for biodiversity conservation, with about 80% of its original expanse having been destroyed by human actions (MITTERMEIER et al. 2004). Amongst the activities that adversely impact the biodiversity of the Cerrado is the construction of hydroelectric power plants (FELFILI et al. 2005) that supply 81% of Brazil's energy output (TOLMASQUIM 2012). From a herpetological point of view, and in spite of the environmental and social impacts (MORET & FERREIRA 2009, PUEYO & FEARNside 2011), studies related to hydroelectric projects in Cerrado have led to the publication of inventories from regions hitherto unexplored, to the expansion of known geographic distributions and even the discovery of new species (e.g. PAVAN & DIXO 2004, MOTT et al. 2008, CINTRA et al. 2009a, SILVA JR. et al. 2009).

The state of Minas Gerais, located in southeastern Brazil, has erected many of its 250 hydroelectric power plants in operation in areas originally covered by Cerrado (ANEEL 2012). However, results of environmental assessments carried out at the hydroelectric plants of Minas Gerais are not usually published in scientific journals. Usually, they tend to be limited to specimens in zoological collections and reports submitted to regulators/inspectors for approval. Besides, although these reports are public, they are not quite readily accessible. In order to encourage the publication of environmental assessment data in scientific journals, the present study provides a list of snake species from the area of the Nova Ponte Hydroelectric Power Plant (NPHPP).

The NPHPP (19°08' S, 47°42' W, ca 800 m a.s.l.) is located in the Araguari River valley, within the limits of the city of Nova Ponte, in the Triângulo Mineiro region, state of Minas Gerais. Plant construction began in 1987, and operations started in 1994, damming up water in a reservoir of 12,792 hm³ (CEMIG 2011). The original vegetation of the region was a mosaic of deciduous and semi-deciduous forests, together with different Cerrado physiognomies (OLIVEIRA-FILHO & FONTES 2000, WERNECK et al. 2000). These vegetation communities were already very modified by human activities at the time of the environmental studies (LEME ENGENHARIA 1990). Later, some areas not yet affected by the plant were declared protected as a compensatory measure and are currently in a regeneration phase; one such example is the Estação de Pesquisa e Desenvolvimento Ambiental Galheiro (Galheiro Research and Environmental Development Station) (WERNECK et al. 2000).

Data used in this study are from the area of influence and the area directly affected by the NPHPP (municipalities of Perdizes, Iraí de Minas, Nova Ponte, Pedrinópolis, Sacramento, Santa Juliana and Serra do Salitre) (Fig. 1), and were obtained by examining: i) the published and publicly accessible environmental assessments on the herpetofauna of the NPHPP, performed between February and August 1987 and January and July 1988 (LEME ENGENHARIA 1990), ii) the snake collections of the Fundação Ezequiel Dias (FUNED), Museu de Zoologia João Moojen, Universidade Federal de Viçosa (MZUFV), Museu Nacional (MNRJ), and Instituto Vital Brazil (IVB), which contain

specimens from Nova Ponte collected between 1988 and 1995; iii) the citation of voucher specimens from the study area in other publications, and iv) from the digital Species Link catalogue (www.splink.org.br) for species that were not recorded by any of the previously mentioned methods.

Specimens examined were re-identified by consulting specific publications, comparing them with other specimens, and with the assistance of experts. Records obtained from the Species Link belonged to Instituto Butantan's collection (IBSP) that was devastated by a fire in 2010.

We recorded 43 snake species in the area of the NPHPP, representing the families Anomalepididae (1 sp.), Boidae (3 spp.), Colubridae (8 spp.), Dipsadidae (24 spp.), Elapidae (2 spp.) and Viperidae (5 spp.) (Tab. 1). Five taxa were recorded only on the basis of the online catalogue of the Instituto Butantan (Species Link), while *Boa constrictor amarali* was only recorded by LEME ENGENHARIA (1990) and the collection of the IBSP; all other taxa are represented by at least one specimen in the collections of FUNED, IVB MZUFV or MNRJ, and/or specimens examined for taxonomic studies (Tab. 1).

All species with vouchers originally existing in the collection of the IBSP were included in the list despite the impossibility of re-examining them. This was done because they are taxa recorded from nearby localities, too (FRANÇA

& ARAÚJO 2007, SAWAYA et al. 2008) and can be expected to also occur in the region of the NPHPP. Nine taxa cited by LEME ENGENHARIA (1990) for the area of NPHPP were not included, because no voucher specimen could be traced or because of taxonomic issues:

Atractus sp. The only species of the genus with an expected occurrence in the study area is *Atractus pantostictus* PUERTO & FERNANDES, 1993 (PASSOS et al. 2010). However, we found no voucher specimen to confirm the record.

Bothrops neuwiedi WAGLER, 1824. Some former subspecies of *B. neuwiedi* are now recognized as good species, such as *Bothrops pauloensis* AMARAL, 1925 (SILVA & RODRIGUES 2008). Given the absence of *B. neuwiedi* records in the Triângulo Mineiro (SILVA & RODRIGUES 2008) and the presence of a voucher of *B. pauloensis* from the NPHPP at FUNED, we consider the record of *B. neuwiedi* by LEME ENGENHARIA (1990) to refer to *B. pauloensis*.

Clelia clelia (DAUDIN, 1803). The taxonomy of *Clelia* has been quite confusing prior to its revision by ZAHER (1996), who restricted the Brazilian populations of *C. clelia* to the Amazon. However, ZAHER (1996) cited a specimen of *Boiruna maculata* (BOULENGER, 1896) from the municipality of Perdizes, which lies within the sampling area of LEME ENGENHARIA (1990). Thus, we excluded *C. clelia* from our list, but included *B. maculata*.

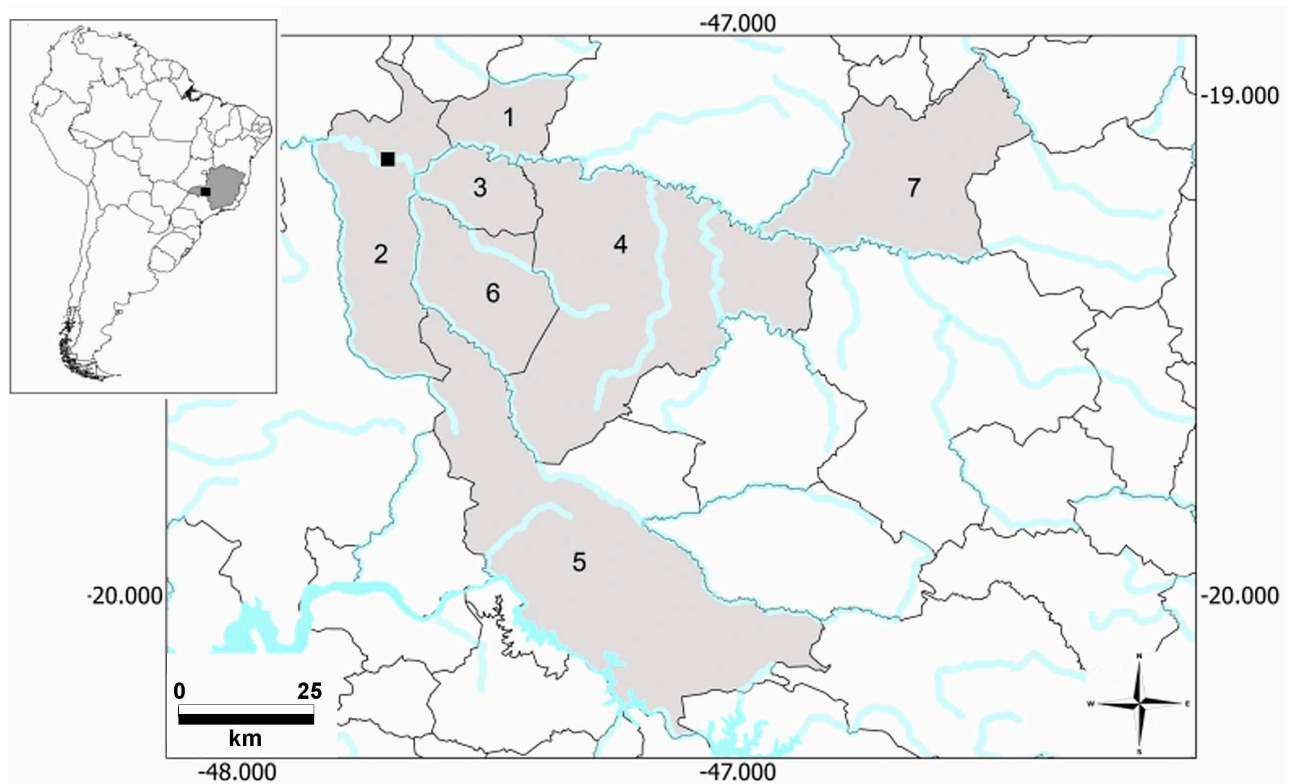


Figure 1. Inset map: South America, with the state of Minas Gerais highlighted in grey and the study area represented by a black square. Main map: detailed representation of the study area. Blue lines: rivers; Black lines: municipality limits; Black square: site of the Nova Ponte Hydroelectric Power Plant. 1: Iraí de Minas; 2: Nova Ponte; 3: Pedrinópolis; 4: Perdizes; 5: Sacramento; 6: Santa Juliana; 7: Serra do Salitre.

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Table 1. Checklist of snakes from the area of influence of the Nova Ponte Hydroelectric Power Plant, Minas Gerais.

Taxon	Source
Anomalepididae Taylor, 1939	
<i>Liotyphlops ternetzii</i> (Boulenger, 1896)	FUNED, MNRJ
Boidae Gray, 1828	
<i>Boa constrictor amarali</i> (Stull, 1932)	LEME ENGENHARIA (1990), IBSP (<i>Species Link</i>)
<i>Corallus hortulanus</i> (Linnaeus, 1758)	MZUFV
<i>Epicrates crassus</i> Cope, 1862	LEME ENGENHARIA (1990), PASSOS & FERNANDES (2008), FUNED
Colubridae Oppel, 1811	
<i>Chironius exoletus</i> (Linnaeus, 1758)	MNRJ
<i>Chironius flavolineatus</i> (Jan, 1863)	FUNED, MNRJ, MZUFV
<i>Chironius quadricarinatus</i> (Boie, 1827)	LEME ENGENHARIA (1990), FUNED, MNRJ, MZUFV
<i>Drymoluber brazili</i> (Gomes, 1918)	FUNED, MZUFV
<i>Drymoluber dichrous</i> (Peters, 1863)	MZUFV
<i>Oxybelis aeneus</i> (Wagler, 1824)	IBSP (<i>Species Link</i>)
<i>Simophis rhinostoma</i> (Schlegel, 1837)	LEME ENGENHARIA (1990), FUNED
<i>Spilotes pullatus pullatus</i> (Linnaeus, 1758)	LEME ENGENHARIA (1990), FUNED
Dipsadidae Bonaparte, 1838	
<i>Apostolepis assimilis</i> (Reinhardt, 1861)	LEME ENGENHARIA (1990), FUNED, MZUFV
<i>Boiruna maculata</i> (Boulenger, 1896)	ZAHER (1996)
<i>Erythrolamprus aesculapii venustissimus</i> Wied, 1821	CURCIO (2008)
<i>Leptodeira annulata pulchriceps</i> Duellman (1958)	FUNED
<i>Liophis almadensis</i> (Wagler, 1824)	FUNED
<i>Liophis jaegeri jaegeri</i> (Günther, 1858)	IBSP (<i>Species Link</i>)
<i>Liophis miliaris orinus</i> (Cope, 1868)	LEME ENGENHARIA (1990), FUNED
<i>Liophis poecilogyrus schotti</i> (Schlegel, 1837)	LEME ENGENHARIA 1990, FUNED, MZUFV
<i>Liophis reginae macrosoma</i> (Amaral, 1936)	MNRJ, FUNED
<i>Oxyrhopus clathratus</i> Duméril, Bibron & Duméril, 1854	MZUFV
<i>Oxyrhopus guibei</i> Hoge & Romano, 1978	FUNED, MZUFV
<i>Oxyrhopus rhombifer rhombifer</i> Duméril, Bibron & Duméril, 1854	LEME ENGENHARIA (1990), MNRJ, FUNED, MZUFV
<i>Oxyrhopus trigeminus</i> Duméril, Bibron & Duméril, 1854	IBSP (<i>Species Link</i>)
<i>Philodryas agassizii</i> (Jan, 1863)	FUNED
<i>Philodryas aestiva</i> (Duméril, Bibron & Duméril, 1854)	IBSP (<i>Species Link</i>)
<i>Philodryas mattogrossensis</i> Koslowsky, 1898	LEME ENGENHARIA (1990), FUNED, MZUFV
<i>Philodryas nattereri</i> Steindachner, 1870	IBSP (<i>Species Link</i>)
<i>Philodryas olfersii</i> (Lichenstein, 1823)	LEME ENGENHARIA (1990), MNRJ, FUNED, MZUFV
<i>Philodryas patagoniensis</i> (Girard, 1858)	LEME ENGENHARIA (1990), FUNED
<i>Taeniophallus occipitalis</i> (Jan, 1863)	FUNED
<i>Thamnodynastes hypoconia</i> (Cope, 1860)	FRANCO & FERREIRA (2003), FUNED
<i>Thamnodynastes rutilus</i> (Prado, 1942)	FRANCO & FERREIRA (2003), FUNED, MZUFV
<i>Xenodon merremii</i> (Wagler, 1824)	LEME ENGENHARIA (1990), FUNED
<i>Xenopholis undulatus</i> (Jensen, 1900)	FUNED, MZUFV
Elapidae Boie, 1827	
<i>Micrurus frontalis</i> (Duméril, Bibron & Duméril, 1854)	LEME ENGENHARIA (1990), FUNED
<i>Micrurus lemniscatus carvalhoi</i> Roze, 1967	LEME ENGENHARIA (1990), IVB
Viperidae Laurenti, 1768	
<i>Bothrops alternatus</i> Duméril, Bibron & Duméril, 1854	LEME ENGENHARIA (1990), IVB
<i>Bothrops itapetiningae</i> (Boulenger, 1907)	LEME ENGENHARIA (1990), FUNED
<i>Bothrops moojeni</i> Hoge, 1966	LEME ENGENHARIA (1990), FUNED, MZUFV
<i>Bothrops pauloensis</i> Amaral, 1925	LEME ENGENHARIA (1990), FUNED
<i>Crotalus durissus terrificus</i> (Laurenti, 1768)	LEME ENGENHARIA (1990), FUNED

Eunectes notaeus COPE, 1862. A species apparently restricted to the La Plata River basin, with higher abundance in the wetlands of the Brazilian Pantanal (SANTOS et al. 2013). The Araguari River (where the NPHPP is located) runs through the La Plata basin, but we are not convinced of the occurrence of *E. notaeus* there without vouchers. However, the presence of *Eunectes murinus* (LINNAEUS, 1758), a widely distributed species (HADDAD Jr. et al., 2012), is expected. Also, misidentification by LEME ENGENHARIA (1990) is not too unlikely, because the main reference employed for the identification of Brazilian snakes in the 1990' (PETERS & OREJAS-MIRANDA 1970) mentions *E. murinus* occurring in the Amazon basin and *E. notaeus* in western Brazil.

Liophis sp. In addition to those confirmed in Table 1, the occurrence of four other species of *Liophis* is possible in the area of NPHPP (DIXON 1989). There are, however, no voucher specimens to confirm their presence.

Mastigodryas bifossatus (RADDI, 1820) and *Sibynomorphus mikanii* (SCHLEGEL, 1837). These species are expected to occur in the area of the NPHPP, since they were recorded from a nearby locality (BRITES & BAUAB 1988).

Phimophis cf. *iglesiassi*. *P. iglesiassi* (GOMES, 1915) occurs in the Caatinga (RODRIGUES 1993), and its presence is not expected in the NPHPP. On the other hand, *P. guerini* (DUMÉRIL, DUMÉRIL & BIBRON, 1854) may possibly occur in the area, as it has been recorded from a nearby locality (BRITES & BAUAB 1988).

Pseudoboa sp. *Pseudoboa nigra* is expected to be present in the area of the NPHPP since it was recorded from a nearby locality (BRITES & BAUAB 1988).

The snake species richness (43) in the area of the NPHPP represents 11, 31, and 27% of the richness of Brazil (386 spp.), Minas Gerais (139 spp.), and the Cerrado (158 spp.), respectively (BÉRNILS et al. 2009, NOGUEIRA et al. 2011, BÉRNILS & COSTA 2012). Compared with other Cerrado regions of central Brazil, such as Uberlândia (BRITES & BAUAB 1988), the Federal District and Unai (FRANÇA & ARAÚJO 2007), Itirapina (SAWAYA et al. 2008), Santa Edwiges Hydroelectric Plant (CINTRA et al. 2009b), and Emas National Park (VALDUJO et al. 2009), the region of the NPHPP stands out as one of the richest in snake species.

The species richness of Cerrado reptiles is explained by the horizontal heterogeneity of the landscape, allowing the coexistence of many taxa (COLLI et al. 2002). This same heterogeneity also favours the coexistence of congeneric species (COLLI et al. 2011). Both situations are observed in the area of the NPHPP, with its high snake species richness, and some genera (*Bothrops*, *Oxyrhopus* and *Philodryas*) represented by four or more species.

Eight species listed here (*Bothrops itapetiningae*, *B. moojeni*, *B. pauloensis*, *Chironius flavolineatus*, *C. quadricarinatus*, *Epicrates crassus*, *Simophis rhinostoma* and *Xenopholis undulatus*) are considered endemic to the Cerrado (NOGUEIRA et al. 2011; see COSTA et al. 2013a for the exclusion of *Drymoluber brazili*). All taxa identified to species level, except *Drymoluber dichrous* and *Oxyrhopus clathratus*, fit the Cerrado biotic elements 1, 2, or

3 (NOGUEIRA et al. 2011), which have most of the Cerrado snake species. This result was expected due to the geographical location of the NPHPP. The percentage of Cerrado endemics present at the NPHPP (18.6%) is lower than the total of endemic snakes from this domain as a whole (32%), or than the endemics of biotic elements 1, 2 and 3 (28%) (NOGUEIRA et al. 2011). This could be a result of the degree of environmental change that the area had already suffered before the construction of the hydroelectric plant (LEME ENGENHARIA 1990), with the possibility of some endemics and species with more specialised environmental requirements having been extinct or become locally rare before the inventory was completed.

Bothrops itapetiningae is the only species of this study that is considered threatened (in the category "Vulnerable") in the state of Minas Gerais (Fundação Biodiversitas 2007). *Philodryas agassizii* and *Xenopholis undulatus*, although listed as not threatened in Minas Gerais (Fundação Biodiversitas 2007), are considered "Vulnerable" in the state of São Paulo where their known records are about 140 km south of the NPHPP reservoir. Little is known about the biology of *X. undulatus* (COSTA et al. 2013b), but *B. itapetiningae* and *P. agassizii* seem to be adapted to living in grasslands with low levels of anthropogenic interference (SAWAYA et al. 2008). It is possible that their occurrence in the region of the NPHPP is currently restricted to the protected areas that have been created after the power plant construction.

Noteworthy are the records of *Drymoluber dichrous* and *Oxyrhopus clathratus* from the NPHPP. *Drymoluber dichrous* occurs in the Amazon and Atlantic Forests, and their transitional areas with the Cerrado. The nearest area of Nova Ponte with a confirmed record of *D. dichrous* is the Ecological Station of Tripuí, about 500 km to the east (COSTA et al. 2013a). *Oxyrhopus clathratus*, on the other hand, is restricted to the Atlantic Forest, and Nova Ponte is the most inland record for the species (BERNARDO et al. 2012). The presence of these two species in the area of the NPHPP might be associated with the persistence of semi-deciduous forest fragments in the region (OLIVEIRA-FILHO & FONTES 2000).

The snake fauna from the NPHPP area is 1.5 times richer than that found in Uberlândia (BRITES & BAUAB 1988), about 80 km to the northwest. This discrepancy might be explained by the study area at the NPHPP having been more expansive, greater habitat heterogeneity, and/or the use of different methods of data collection (comp. LEME ENGENHARIA 1990). Of the 28 species recorded in Uberlândia, only four were not recorded at the NPHPP: *Clelia clelia*, *Pseudoboa nigra*, *Sibynomorphus turgidus* and *Thamnodynastes strigilis*. Currently, *C. clelia* is not a suitable name for the Cerrado specimens (see above), and *T. strigilis* is an invalid name previously used for some species now considered distinct, like *T. hypoconia*, which has been listed for the NPHPP (FRANCO & FERREIRA 2003). The similarity in the snake faunas of Uberlândia and the NPHPP suggests a high degree of environmental similarity between both areas.

Although several collection methods have been used in the NPHPP area between 1987 and 1988, this issue was not addressed by LEME ENGENHARIA (1990), except in conjunction with the number of specimens of venomous snakes captured by local collectors: 305 *Crotalus durissus terrificus*, 17 *Bothrops alternatus*, five *B. itapetiningae*, 75 *B. pauloensis*, 19 *B. moojeni*, two *Micrurus frontalis*, and one *M. lemniscatus carvalhoi*. The low frequency of *Micrurus* spp. can be explained by their fossorial habits (LEME ENGENHARIA 1990, SAWAYA et al. 2008). Nevertheless, the high abundance of *C. d. terrificus* may be a result of its wide distribution and high degree of adaptability to altered areas (BASTOS et al. 2005). The low abundance of *B. itapetiningae*, even if compared to other *Bothrops* species, might be a result of a naturally low density in the region, or it could be related to its requiring habitats with low levels of anthropogenic interference (LEME ENGENHARIA 1990).

The region of Nova Ponte is of high priority for the conservation of the herpetofauna of Minas Gerais (DRUMMOND et al. 2005). Its high snake species richness, including some Cerrado endemics and one threatened species, reinforces this view. However, data provided here come from areas that are for the largest part submerged after the dam was flooded. Therefore, it is critical that further studies be conducted in the localities that became protected areas after the construction of the NPHPP (e.g., Galheiro Station). This would update the regional list of species, provide new information on their conservation status, and contribute further to the knowledge of the snake fauna of the Triângulo Mineiro.

Acknowledgements

We thank RHAIZA ESTES and ANÍBAL MELGAREJO (IVB), PAULO PASSOS and RONALDO FERNANDES (MNRJ) for information on specimens in their care. We also thank BRYAN JENNINGS (MNRJ) for pertinent comments and his revision of a previous version of our manuscript. RCG thanks the CNPq for financial support. RNF thanks the CNPq for their productivity fellowship. Identification of specimens from FUNED was funded by the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) through the Programa Biota Minas.

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Appendix

Specimens examined by the authors

Apostolepis assimilis: FUNED 816, MZUFV 795. *Boa constrictor amarali*: IBSP 15417 (Species Link). *Bothrops alternatus*: IVB 284, 301. *B. itapetiningae*: FUNED 021, 030. *B. moojeni*: FUNED 792, MZUFV 761, 791, 792. *Chironius exoletus*: MNRJ 4681. *C. flavolineatus*: FUNED 759, 761, MNRJ 4696, MZUFV 778. *C. quadricarinatus*: FUNED 760, 763, 770, 776, 782, 788, 789, 793–795, MNRJ 4651–4654, 4667, 4668, 4682, 4683. MZUFV 732–735. *Corallus hortulanus*: MZUFV 1016. *Crotalus durissus terrificus*: FUNED 767, 784, 791, 796, 919–928, 1001, 1002, 1171, 2527. *Drymoluber brazili*: FUNED 807, MZUFV 780. *D. dichrous*: MZUFV 779. *Epicrates crassus*: FUNED 381. *Leptodeira annulata pulchriiceps*: FUNED 781. *Liophis almadensis*: FUNED 808, 850. *L. jaegeri jaegeri*: IBSP 46602 (Species Link). *L. miliaris orinus*: FUNED 798. *L. poecilogyrus schotti*: FUNED 771, 777, 783, 804, 948, 949, 1137. MZUFV 572. *L. reginae macrosoma*: FUNED 802, 803, 1194, MNRJ 9042. *Liotyphlops ternetzii*: FUNED 800, MNRJ 8147. *Micrurus frontalis*: FUNED 1111, 2445. *M. lemniscatus carvalhoi*: IVB 528. *Oxybelis aeneus*: IBSP 49664 (Species Link). *Oxyrhopus clathratus*: MZUFV 777. *O. guibei*: FUNED 764, 768, 769, 787, 801, MZUFV 573, 576. *O. rhombifer rhombifer*: FUNED 799, MZUFV

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574, MNRJ 9041. *O. trigeminus*: IBSP 881 (Species Link). *Philodryas aestiva*: IBSP 15537 (Species Link). *P. agassizii*: FUNED 805. *P. mattogrossensis*: FUNED 987, MZUFV 798. *P. nattereri*: IBSP 49776 (Species Link). *P. olfersii*: FUNED 766, 773, 785, MZUFV 737, MNRJ 4622, 4624, 4626–4631, 4633, 4694. *Philodryas patagoniensis*: FUNED 772, 774, 775. *Spilotes pullatus pullatus*: FUNED 758, 790, 1422. *Taeniophallus occipitalis*: FUNED 951. *Thamnodynastes hypoconia*: FUNED 762, 780. *T. rutilus*: FUNED 809–815, 1172, MZUFV 794. *Xenodon merremii*: FUNED 797. *Xenopholis undulatus*: FUNED 746, 1136, MZUFV 763.